CLAIMS

1. A method of determining one or more properties of a body positioned proximate an array of coils having one or more resonant properties, the method comprising acts of:

detecting a change in at least one resonant property of at least one of the coils in the array; and

determining at least one electromagnetic property of at least one region of the body from the change in the at least one resonant property.

2. The method of claim 1, wherein the act of detecting the change in at least one resonant property includes an act of detecting a change in at least one resonant frequency of at least one of the coils in the array.

3. The method of claim 1, wherein the act of determining the at least one electromagnetic property includes an act of determining at least one of a conductivity, a permittivity, and a permeability of the at least one region of the body.

4. The method of claim 1, wherein the act of determining the at least one electromagnetic property includes an act of determining at least one of a magnitude, a direction, and a phase of an electric field at the at least one region of the body.

5. The method of claim 1, wherein the act of determining the at least one electromagnetic property includes an act of determining at least one of a magnitude, a direction, and a phase of a magnetic field at the at least one region of the body.

6. The method of claim 1, further comprising an act of forming an image having a plurality of voxels, each voxel of the plurality of voxels having an intensity related to a respective one of the at least one electromagnetic property.

7. The method of claim 1, wherein the act of detecting a change in the at least one resonant property includes an act of measuring at least one property of the array of coils indicative of the change in the at least one resonant property.

8. The method of claim 7, wherein the act of measuring at least one property includes an act of measuring an impedance characteristic of at least one of the coils in the array.

9. The method of claim 8, wherein the act of measuring an impedance characteristic includes an act of obtaining a measured impedance matrix of the array of coils.

10. The method of claim 9, wherein the act of obtaining the measured impedance matrix includes an act of obtaining a plurality of scattering parameters (S-parameters) of the array of coils.

11. The method of claim 7, wherein the act of measuring at least one property includes an act of providing at least one electrical stimulus to at least one of the coils in the array.

12. The method of claim 11, wherein the act of providing at least one electrical stimulus includes an act of providing at least one of a current and a voltage to the at least one coil.

13. The method of claim 11, wherein the act of providing the electrical stimulus includes an act of providing an electrical stimulus having a range of frequencies and the act of measuring the at least one property includes an act of measuring at least one S-parameter of the array of coils.

14. The method of claim 13, wherein the act of measuring the at least one S-parameter includes an act of measuring a voltage in the at least one other of the coils in the array.

15. The method of claim 13, wherein the act of measuring at least one S-parameter includes an act of providing the electrical stimulus in one of the coils in the array and measuring the at least one property in each of the coils in the array.

16. The method of claim 15, wherein the act of measuring at least one S-parameter includes an act of measuring a plurality of S-parameters in part by producing a current in each of the coils in the array and measuring a voltage in each of the coils in the array, respectively, in response to the current.

17. The method of claim 16, wherein the act of measuring at least one property includes an act of obtaining a measured impedance matrix formed from the plurality of S-parameters.

18. The method of claim 8, wherein the act of determining at least one electromagnetic property includes an act of computing a trial impedance matrix from trial values of at least one of conductivity, permittivity and permeability for the at least one region of the body.

19. The method of claim 18, wherein the act of computing a trial impedance matrix includes computing values of the trial impedance matrix by solving Maxwell's equations with the trial values.

20. The method of claim 19, wherein the act of computing a trial impedance matrix includes computing the trial impedance matrix according to the expression:

$$Z_{ij} = \int_V \left\{ \sigma(x) \vec{E}_i^*(x) \cdot \vec{E}_j(x) - i\omega \left[\varepsilon(x) \vec{E}_i^*(x) \cdot \vec{E}_j(x) - \mu(x)^{-1} \vec{B}_i^*(x) \cdot \vec{B}_j(x) \right] \right\} + \int_S \vec{E}_i(x) \times \vec{B}_j^*(x) \cdot d\vec{S} .$$

21. The method of claim 19, wherein the act of computing the trial impedance matrix includes employing a finite difference time domain (FDTD) simulation of a model of the array and the body to compute a plurality of currents flowing in a plurality of coils in the array in response to a plurality of voltages and computing impedance characteristics from the plurality of currents and the plurality of voltages.

22. The method of claim 18, wherein the act of determining at least one electromagnetic property includes an act of comparing the trial impedance matrix with the measured impedance matrix.

23. The method of claim 21, wherein the act of determining at least one electromagnetic property includes an act of reducing a distance between the trial impedance matrix and the measured impedance matrix.

24. The method of claim 23, wherein the act of reducing the distance includes iteratively updating the trial impedance matrix by updating trial values that decrease the distance from the measured impedance matrix to provide a final trial impedance matrix.

25. The method of claim 24, wherein the act of reducing the distance includes an act of determining a least squares distance.

26. The method of claim 24, wherein the act of determining at least one electromagnetic property includes an act of forming an image of the body, the image having a plurality of voxels, each voxel of the plurality of voxels having an intensity based on corresponding trial values used to compute the final trial impedance matrix.

27. The method of claim 8, wherein the act of determining at least one electromagnetic property includes providing a model of the array of coils and the body.

28. The method of claim 27, wherein the act of providing a model includes an act of logically partitioning a volume of space including at least a portion of the body into a plurality of regions.

29. The method of claim 28, wherein the act of determining at least one magnetic property includes an act of assigning at least one of a conductivity value, a permittivity value, and a permeability value to each of the plurality of regions.

30. The method of claim 29, wherein the act of determining at least one electromagnetic property includes an act of computing a trial impedance matrix from the assigned conductivity, permittivity and permeability values according to the model.

31. The method of claim 30, wherein the act of determining at least one electromagnetic property includes an act of reducing a distance between the trial impedance matrix and the measured impedance matrix by iteratively adjusting trial values of the assigned conductivity and permittivity values

32. The method of claim 31, wherein the act of computing the trial impedance matrix includes an act of performing a finite difference time domain simulation of the model.

33. A method of determining one or more properties of a body, the method comprising acts of:

positioning the body proximate a plurality of coils;

measuring at least one property of at least one of the plurality of coils; and

determining at least one electromagnetic property of at least one region of the body from the at least one property based on at least two of a resistive coupling, a capacitive coupling, and an inductive coupling between at least two of the plurality of coils.

34. The method of claim 33, wherein the act of determining at least one electromagnetic property includes an act of determining at least one of a conductivity, a permittivity, and a permeability of the at least one region of the body.

35. The method of claim 33, wherein the act of determining the at least one electromagnetic property includes an act of determining at least one of a magnitude, a direction, and a phase of an electric field at the at least one region of the body.

36. The method of claim 33, wherein the act of determining the at least one electromagnetic property includes an act of determining at least one of a magnitude, a direction, and a phase of a magnetic field at the at least one region of the body.

37. The method of claim 33, further comprising an act of forming an image having a plurality of voxels, each voxel of the plurality of voxels having an intensity related to a respective one of the at least one electromagnetic property.

38. The method of claim 33, wherein the act of measuring at least one property includes an act of measuring an impedance of at least one of the plurality of coils.

39. The method of claim 38, wherein the act of measuring an impedance includes an act of obtaining a measured impedance matrix of the plurality of coils.

40. The method of claim 39, wherein the act of measuring an impedance matrix includes measuring at least one scattering parameter (S-parameter) of at least one of the plurality of coils.

41. The method of claim 40, wherein the act of measuring at least one S-parameter includes an act of providing a current in at least one of the plurality of coils and measuring the at least one property in at least one other of the plurality of coils.

42. The method of claim 41, wherein the act of measuring the at least one property includes an act of measuring a voltage in the at least one other of the plurality of coils.

43. The method of claim 42, wherein the act of measuring the at least one property includes an act of measuring an S11 parameter of the at least one other of the plurality of coils.

44. The method of claim 41, wherein the act of measuring at least one S-parameter includes an act of providing the current in one of the plurality coils and measuring the at least one property in each other of the plurality of coils.

45. The method of claim 44, wherein the act of measuring at least one S-parameter includes an act of measuring a plurality of S-parameters in part by producing current in each of the plurality of coils and measuring a voltage in each other of the plurality of coils, respectively, in response to the current.

46. The method of claim 39, wherein the act of determining at least one electromagnetic property includes computing a trial impedance matrix from trial values of at least one of conductivity and permittivity for the at least one region of the body.

47. The method of claim 46, wherein the act of computing the trial impedance matrix includes computing values of the trial impedance matrix by solving Maxwell's equations in part with the trial values.

48. The method of claim 46, wherein the act of computing the trial impedance matrix includes computing the trial impedance matrix according to the expression:

$$Z_{ij} = \int_V \left\{ \sigma(x)\vec{E}_i^*(x)\cdot\vec{E}_j(x) - i\omega\left[\varepsilon(x)\vec{E}_i^*(x)\cdot\vec{E}_j(x) - \mu(x)^{-1}\vec{B}_i^*(x)\cdot\vec{B}_j(x)\right]\right\} + \int_S \vec{E}_i(x)\times\vec{B}_j^*(x)\cdot d\vec{S}\,.$$

49. The method of claim 19, wherein the act of computing the trial impedance matrix includes employing a finite difference time domain (FDTD) simulation of a model of the array and the body to compute a plurality of currents flowing in a plurality of coils in the array in response to a plurality of voltages and computing impedance characteristics from the plurality of currents and the plurality of voltages.

50. The method of claim 46, wherein the act of determining at least one electromagnetic property includes an act of comparing the trial impedance matrix with the measured impedance matrix.

51. The method of claim 49, wherein the act of determining at least one electromagnetic property includes an act of reducing a distance between the trial impedance matrix and the measured impedance matrix.

52. The method of claim 51, wherein the act of reducing the distance includes iteratively updating the trial impedance matrix with update trial values that decrease the distance from the measured impedance matrix to provide a final trial impedance matrix.

53. The method of claim 52, wherein the act of reducing the distance includes an act of iteratively determining a least squares distance.

54. The method of claim 52, wherein the act of determining at least one electromagnetic property includes an act of forming an image of the body, the image having a plurality of voxels, each voxel of the plurality of voxels having an intensity based on corresponding updated trial values used to compute the final trial impedance matrix.

55. The method of claim 39, wherein the act of determining at least one electromagnetic property includes providing a model of the array of coils and the body.

56. The method of claim 55, wherein the act of providing a model includes an act of logically partitioning a volume of space including at least a portion of the body into a plurality of regions.

57. The method of claim 56, wherein the act of determining at least one electromagnetic property includes an act of assigning a conductivity value and a permittivity value to each of the plurality of regions.

58. The method of claim 57, wherein the act of determining at least one electromagnetic property includes an act of computing a trial impedance matrix from the assigned conductivity and permittivity values according to the model.

59. The method of claim 58, wherein the act of determining at least one electromagnetic property includes an act of reducing a distance between the trial impedance matrix and the measured impedance matrix by iteratively adjusting the values of the assigned conductivity and permittivity values.

60. The method of claim 59, wherein the act of computing the trial impedance matrix includes an act of performing a finite difference time domain simulation of the model.

61. An apparatus for determining one or more properties of a body, the apparatus comprising:

a plurality of coils having one or more resonant properties;

a first component coupled to the plurality of coils and adapted to provide at least one measurement of the plurality of coils indicative of a change in at least one resonant property of at least one of the plurality of coils; and

a second component coupled to the first component to receive the at least one measurement, the second component adapted to determine at least one electromagnetic property of at least one region of the body based on the change in the at least one resonant property.

62. The apparatus of claim 61, wherein the at least one resonant property includes at least one resonant frequency of at least one of the coils in the array.

63. The apparatus of claim 61, wherein the at least one electromagnetic property includes at least one of a conductivity, a permittivity, and a permeability of the at least one region of the body.

64. The apparatus of claim 61, wherein the at least one electromagnetic property includes at least one of a magnitude, a direction, and a phase of an electric field at the at least one region of the body.

65. The apparatus of claim 61, wherein the at least one electromagnetic property includes at least one of a magnitude, a direction, and a phase of a magnetic field at the at least one region of the body.

66. The apparatus of claim 61, wherein the second component is adapted to form an image having a plurality of voxels, each voxel of the plurality of voxels having an intensity related to a respective one of the at least one electromagnetic property.

67. The apparatus of claim 61, wherein the first component is adapted to measure an impedance of at least one of the plurality of coils.

68. The apparatus of claim 62, wherein the first component is adapted to obtain a measured impedance matrix of the plurality of coils.

69. The apparatus of claim 68, wherein the first component is adapted to measure at least one scattering parameter (S-parameter) of at least one of the plurality of coils.

70. The apparatus of claim 61, wherein the first component includes at least one of a matching circuit and a network analyzer.

71. The apparatus of claim 69, further comprising a third component adapted to provide a current in at least one of the plurality of coils and the first component is adapted to measure the at least one property in at least one other of the plurality of coils in response to the current.

72. The apparatus of claim 71, wherein the third component includes an radio frequency (RF) power source.

73. The apparatus of claim 71, wherein the first component is adapted to measure a voltage in the at least one other of the plurality of coils in response to the current.

74. The apparatus of claim 73, wherein the first component is adapted to measure an S11 parameter of the at least one other of the plurality of coils at a plurality of frequencies.

75. The apparatus of claim 68, wherein the first component is adapted to measure the at least one property in each of the other coils in the array in response to the current.

76. The apparatus of claim 68, wherein the second component is adapted to compute a trial impedance matrix from trial values of at least one of conductivity and permittivity for the at least one region of the body.

77. The apparatus of claim 76, wherein the second component is adapted to compute values of the impedance matrix by solving Maxwell's equations in part with the trial values.

78. The apparatus of claim 76, wherein the second component computes the trial impedance matrix according to the expression:

$$Z_{ij} = \int_V \left\{ \sigma(x) \vec{E}_i^*(x) \cdot \vec{E}_j(x) - i\omega \left[\varepsilon(x) \vec{E}_i^*(x) \cdot \vec{E}_j(x) - \mu(x)^{-1} \vec{B}_i^*(x) \cdot \vec{B}_j(x) \right] \right\} + \int_S \vec{E}_i(x) \times \vec{B}_j^*(x) \cdot d\vec{S} .$$

79. The apparatus of claim 76, wherein the second component is adapted to compare the trial impedance matrix with the measured impedance matrix.

80. The apparatus of claim 79, wherein the second component determines at least one electromagnetic property in part by reducing a distance between the trial impedance matrix and the measured impedance matrix.

81. The apparatus of claim 80, wherein the second component reduces the distance in part by iteratively updating the trial impedance matrix with updated trial values that decrease the distance from the measured impedance matrix to provide a final trial impedance matrix.

82. The apparatus of claim 81, wherein the second component determines a least squares distance between the trial impedance matrix and the measured impedance matrix.

83. The apparatus of claim 81, wherein the second component is adapted to form an image having a plurality of voxels, each voxel of the plurality of voxels having an intensity corresponding to one of the updated trial values used to compute the final trial impedance matrix.

84. The apparatus of claim 68, wherein the second component provides a model of the plurality of coils and the body.

85. The apparatus of claim 84, wherein the model includes a logically partitioned volume of space having a plurality of regions, the plurality of regions including at least a portion of the body.

86. The apparatus of claim 85, wherein each of the plurality of regions is assigned a conductivity value and a permittivity value.

87. The apparatus of claim 86, wherein the second component computes a trial impedance matrix from the assigned conductivity and permittivity values according to the model.

88. The apparatus of claim 87, wherein the second component reduces a distance between the trial impedance matrix and the measured impedance matrix by iteratively adjusting trial values of the assigned conductivity and permittivity values.

89. The apparatus of claim 87, wherein the trial impedance matrix is computed by an finite difference time domain simulation of the model.

90. The apparatus of claim 61, wherein the second component includes:

at least one computer readable medium encoded with instructions; and

at least one processor coupled to the at least one computer readable medium, the at least one processor configured to execute the instructions.

91. An apparatus for determining one or more properties of a body, the apparatus comprising:

a plurality of coils;

a first component coupled to the plurality of coils, the first component adapted to provide at least one measurement of at least one property of the plurality of coils; and

a second component coupled to the first component to receive the at least one measurement, the second component adapted to determine at least one electromagnetic property of at least one region of the body from the at least one measurement based on at least

two of a resistive coupling, a capacitive coupling, and an inductive coupling between two or more of the plurality of coils.

92. The apparatus of claim 91, wherein the at least one electromagnetic property includes at least one of a conductivity, a permittivity and a permeability of the at least one region of the body.

93. The apparatus of claim 91, wherein the at least one electromagnetic property includes at least one of a property of at least one of a magnetic and electric at the at least one region of the body.

94. The apparatus of claim 91, wherein the first component is adapted to measure an impedance of at least one of the plurality of coils.

95. The apparatus of claim 94, wherein the first component is adapted to obtain a measured impedance matrix of the plurality of coils.

96. The apparatus of claim 95, wherein the first component is adapted to measure at least one scattering parameter (S-parameter) of at least one of the plurality of coils.

97. The apparatus of claim 96, wherein the first component includes at least one of a matching circuit and a network analyzer.

98. The apparatus of claim 95, further comprising a third component adapted to provide a current in at least one of the plurality of coils and the first component is adapted to measure the at least one property in at least one other of the plurality of coils in response to the current.

99. The apparatus of claim 98, wherein the third component includes an radio frequency (RF) power source.

100. The apparatus of claim 98, wherein the first component is adapted to measure a voltage in the at least one other of the plurality of coils in response to the current.

101. The apparatus of claim 95, wherein the first component is adapted to provide at least one measurement of the at least one property in each of the other coils in the array in response to the current.

102. The apparatus of claim 95, wherein the second component is adapted to compute a trial impedance matrix from trial values of at least one of conductivity, permittivity, and permeability for the at least one region of the body.

103. The apparatus of claim 102, wherein the second component is adapted to compute values of the impedance matrix by solving Maxwell's equations in part with the trial values.

104. The apparatus of claim 102, wherein the second component computes the trial impedance matrix according to the expression:

$$Z_{ij} = \int_V \left\{ \sigma(x) \vec{E}_i^*(x) \cdot \vec{E}_j(x) - i\omega \left[\varepsilon(x) \vec{E}_i^*(x) \cdot \vec{E}_j(x) - \mu(x)^{-1} \vec{B}_i^*(x) \cdot \vec{B}_j(x) \right] \right\} + \int_S \vec{E}_i(x) \times \vec{B}_j^*(x) \cdot d\vec{S} \,.$$

105. The apparatus of claim 102, wherein the second component is adapted to compare the trial impedance matrix with the measured impedance matrix.

106. The apparatus of claim 105, wherein the second component determines at least one electromagnetic property in part by reducing a distance between the trial impedance matrix and the measured impedance matrix.

107. The apparatus of claim 106, wherein the second component reduces the distance in part by iteratively updating the trial impedance matrix in a direction that decreases the distance from the measured impedance matrix.

108. The apparatus of claim 107, wherein the second component determines a least squares distance between the trial impedance matrix and the measured impedance matrix.

109. The apparatus of claim 107, wherein the second component is adapted to form an image having a plurality of voxels, each voxel of the plurality of voxels having an intensity corresponding to one of the updated trial values used to compute the final trial impedance matrix.

110. The apparatus of claim 95, wherein the second component provides a model of the plurality of coils and the body.

111. The apparatus of claim 110, wherein the model includes a logically partitioned volume of space having a plurality of regions, the plurality of regions including at least a portion of the body.

112. The apparatus of claim 111, wherein each of the plurality of regions is assigned a conductivity value and a permittivity value.

113. The apparatus of claim 112, wherein the second component computes a trial impedance matrix from the assigned conductivity and permittivity values according to the model.

114. The apparatus of claim 112, wherein the second component reduces a distance between the trial impedance matrix and the measured impedance matrix by iteratively adjusting trial values of the assigned conductivity and permittivity values.

115. The apparatus of claim 112, wherein the trial impedance matrix is computed by an finite difference time domain simulation of the model.

116. The apparatus of claim 91, wherein the second component includes:

at least one computer readable medium encoded with instructions; and

at least one processor coupled to the at least one computer readable medium, the at least one processor configured to execute the instructions.

117. A computer readable medium encoded with instructions capable of being executed on at least one processor, the instructions, when executed by the at least one processor, performing a method of determining one or more properties of a body positioned proximate a coil array, the method comprising acts of:

defining an electromagnetic model of the coil array;

receiving an input including a measured impedance matrix of the coil array;

logically partitioning a volume associated with the model of the coil array and the body into a plurality of regions;

assigning trial values respectively to each of the plurality of regions, the trial values including at least one of conductivity, permittivity and permeability;

generating a trial impedance matrix from the assigned trial values according to the electromagnetic model of the coil array; and

reducing a distance between the trial impedance matrix and the measured impedance matrix.

118. The computer readable medium of claim 117, wherein the act of generating the trial impedance matrix includes an act of generating the trial impedance matrix by implementing a finite difference time domain simulation of the model.

119. The computer readable medium of claim 117, wherein the act of reducing the distance includes determining a least squares distance between the trial impedance matrix and the measured impedance matrix by iteratively updating the conductivity and permittivity values such that the trial impedance matrix is closer to the measured impedance matrix on each iteration.